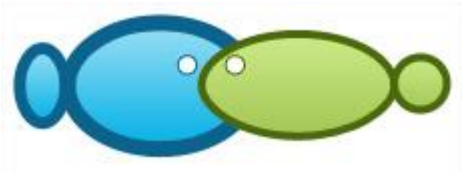

Ecological sustainability status of the Beloso fish (*Glossogobius* sp.) in the Tempe Lake, South Sulawesi, Indonesia

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Abstract. Beloso fish (*Glossogobius* sp.), locally known as "bungo", is one of the freshwater fish of Tempe Lake. Being less bony, tasty, with a thick flesh, it is a sought-after commodity on the local market. Although Beloso fish is ecologically and economically important, its aquaculture has not yet been developed. The high fishing pressure put on the wild population of *Glossogobius* sp.in order to meet high market demand, is currently very concerning. In addition, fish introduced into the Tempe Lake for aquaculture purposes, such as the common carp (*Cyprinus carpio*), are threats to the existence of Beloso fish and other native species, due to either predation or competition. This study aimed to analyze the sustainability and, in particular, the ecological status of the *Glossogobius* sp. located in Tempe Lake. The study was conducted in three districts, namely Wajo, Soppeng and Sidrap, South Sulawesi. Five sites were used during the study period: the middle of Tempe Lake, the water entry of the Bila River, the water entry of the Walanae River, the water entry of the Batu-Batu River and the area of water discharge into the Cenranae River. Sampling, measuring and weighing of fish samples were carried out for data collection. The Rapid Appraisal Analysis (Rapfish) was applied for a sustainability analysis. The measured indicators of ecological sustainability were: the water quality, frequency distribution, age group, growth, mortality, exploitation rate. The result of the Rapfish analysis showed that the value of the sustainability index for the ecology dimension was at 32.68, which means that the Beloso fish's ecological sustainability status can be classified as "less sustainable".
Key Words: bungo, ecological dimension, sustainability, rapid appraisal analysis.

Introduction. Tempe Lake is known as the largest lake in South Sulawesi. It is located in three administrative regions including Wajo, Sidrap and Soppeng districts in South Sulawesi (Limnology Research Center 2012). The lake's volume and surface is strongly affected by the season. The surface area of the lake can reach 35,000 ha in the rainy season, while in the dry season it only reaches 1,000 ha and under normal conditions it can reach between 15,000 and 20,000 ha. Tempe Lake has been a natural habitat for many freshwater fish (Hadijah et al 2019). Beloso fish (*Glossogobius* sp.), locally known as "bungo", is one of the freshwater fish of Tempe Lake, being tasty, less bony and having a thick flesh (Hadijah et al 1998), which makes it a sought-after commodity on the local market (Hadijah et al 2014). Although *Glossogobius* sp. is ecologically and economically important, it has not been aquacultured yet (Hadijah et al 2011). Fish from the Gobidae family (a different species from the beloso fish), is also one of the most popular wild fish species and is used as fish food by the people around the Laguna Lake, northern Philippines (Mendosa et al 2021).

The existence of the wild population of *Glossogobius* sp. is currently very concerning, due to a high fishing pressure put on it, in order to meet the high market demand. In addition, fish introduced for aquaculture purposes into the Tempe Lake, such as common carp (*Cyprinus carpio*), are threats to the existence of *Glossogobius* sp. The

introduced fish cause pressure the on native species, either by predation or by competition (Wijeyaratne & Perera 2001). This study aimed to analyze the ecological sustainability status of *Glossogobius* sp. located in the Tempe Lake.

Material and Method

This study was conducted in three districts: Wajo, Soppeng and Sidrap, South Sulawesi, from February to July 2016. Five sites were used during thee study period, including the middle of Tempe Lake, the water entry of the Bila River, the water entry of the Walanae River, the water entry of the Batu-Batu River and the area of water discharge to the Cenranae River, as it can be seen in Figure 1.

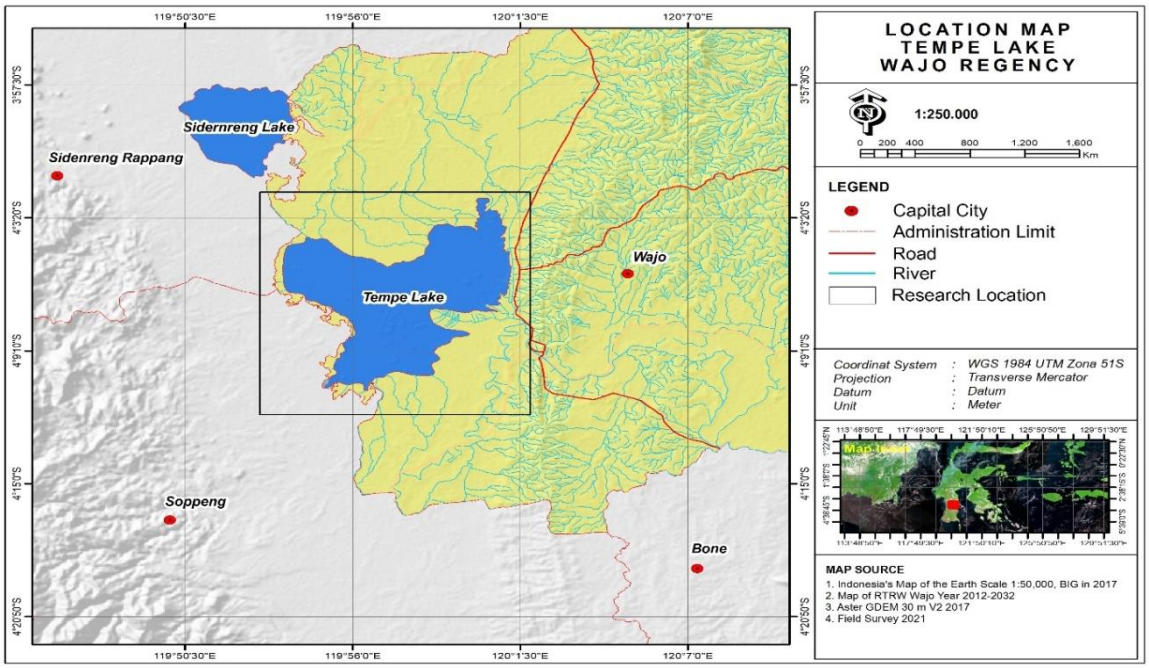

Figure 1. Map of the research location.

Data collection. Post facto survey was applied in this study. Each station was determined based on several criteria, including the (1) suitability as a fish habitat, (2) the viability for sampling and (3) fish diversity. Sampling of *Glossogobius* sp. at each of the five locations was carried out measuring the length of the fish using a ruler and weighing the fish using a digital scale, the results of measuring and weighing the fish were then recorded as research data. A Rapid Appraisal Analysis (Rapfish) was applied for the sustainability evaluation of the fish management, according to Pattimahu (2010), consisting of the following stages:

1. determining the ecological sustainability indicators of *Glossogobius* sp.;
2. assigning to each ecological indicator an ordination scale, according to the sustainability criteria evaluation by a Multidimensional Scaling (MDS);
3. compiling the ecological sustainability index of the fish management in the Tempe Lake.

In addition, the scoring was based on Rapfish, a technique developed by the University of British Columbia for fisheries resources to evaluate the sustainability of fishery resources in a multidisciplinary manner. Rapfish is used to explain the ecological, economic, social, legal/policy dimensions that include sustainability indicators (Pattimahu 2010). Briefly, Rapfish analysis was used to determine the sustainability status of the four dimensions mentioned above. To describe the actual condition of *Glossogobius* sp. from each of these dimensions, the data is processed using descriptive analysis, then the determination of the score on the sustainability status indicator on the dimensions of the Rapfish analysis. In this study, the analysis is the ecological dimension. MDS is used to determine the good or bad condition of the ecological dimension criteria. The results of the MDS analysis

show the status of the ecological dimensions of the management of *Glossogobius* sp. For each indicator, the score reflected the ecological sustainability condition. The score range was defined based on the criteria derived from the observation and analysis of secondary data, with values as follows: 0 for poor, 1 for medium and 2 for good status. Poor values reflect the most unfavorable conditions for sustainable fish management, otherwise the good values reflect the most favorable conditions (Pattimahu 2010).

Results and Discussion

Collected data and literature review were used to assess the condition of sustainability status of fisheries management in the Tempe Lake. Sustainability indicators and scores are presented in Table 1.

Table 1

Ecological indicator and sustainability score of *Glossogobius* sp.

Ecological dimension and indicator	*Score*	*Score criteria*		*Scale*	*References*
		Good	*Poor*		
Water quality	0;1;2	2	0	(0) poor (1) moderate (2) good	FAO (1999); Pitcher & Pereiskhot (2001); Osmaleli (2014)
Length frequency distribution	0;1;2	2	0	(0) poor (1) moderate (2) high	FAO (1999); Pitcher & Pereiskhot (2001)
Group of age	0;1;2	2	0	(0) low (1) moderate (2) high	FAO (1999); Pitcher & Pereiskhot (2001); Osmaleli (2014)
Growth	0;1;2	2	0	(0) low (1) moderate (2) high	FAO (1999); Pitcher & Pereiskhot (2001); Osmaleli (2014)
Mortality	0;1;2	2	0	(0) high (1) moderate (2) low	FAO (1999); Pitcher & Pereiskhot (2001)
Exploitation rate	0;1;2	2	0	(0) high (1) moderate (2) low	FAO (1999); Pitcher & Pereiskhot (2001); Osmaleli (2014)

In order to determine the sustainability status of fisheries' management, a multi-dimensional analysis was applied. The assessment of the sustainability status by index values was categorized according to Kavanagh (1999), as follows:

- index value 0-24.99 (unsustainable);
- index value 25-49.99 (less sustainable);
- index value 50-74.99 (fairly sustainable);
- index value 75-100 (sustainable).

Rapfish was applied for assessing the ecological sustainability status of *Glossogobius* sp., in the waters of Lake Tempe. Six indicators of the ecological dimension were considered, as follows:

a) Water quality

The results of water quality parameters measurement were: temperature of 27.7°C, brightness of 31.13 cm, dissolved oxygen of 4.48-6.96 mg L^{-1} and pH of 6-7.5. All water quality parameters were considered at a good level for fish survival.

b) Frequency distribution

In the present study, the length frequency distribution was from 88 to 231 mm, while the length frequency distribution during the 10 previous years ranged from 50 to 370 mm (Hadijah et al 2019), showing a decrease of the length for larger specimens and an increase of the length of the small fish. Hence, the score given to this indicator was 1,

which means that the length frequency distribution of *Glossogobius* sp. in Tempe Lake was classified as moderate.

c) Age group

The results showed that the cohorts' age ranged from 2 to 3, while the normal cohort population has a range of 5 to 7 (Hadijah et al 2019). This shows that the existence of *Glossogobius* sp. was under pressure, due to the high exploitation rate. Thus, the score given was 0, which means that the age group of the *Glossogobius* sp. is low.

d) Growth rate

The result showed that the growth coefficient was at 0.64, with an average length of infinity of 294.9 mm. This indicates that the length growth is very small, with a low average length of infinity. Thus, the score was 0.

e) Mortality

Determination of the total mortality of *Glossogobius* sp. in Tempe Lake was calculated using the length converted catch curve method proposed by Pauly (1984) with the following formula:

$$\frac{L_n(N_i)}{\Delta t} = a + b.t\ (L_t)$$

Where:

N_i - the number of fish in each i-length size class;

a and b - regression coefficients;

t - the time it takes to grow along a long class.

The result showed that total mortality of fish was 4.162, with a natural mortality coefficient of 0.70 and a catch mortality coefficient of 3.46. This indicates that mortality has exceeded the normal thresholds: the normal value of natural mortality is 0.5 and the normal threshold value of catch mortality is 1 (Hadijah et al 2019). Thus, the score for this indicator is 0, which means a high mortality of *Glossogobius* sp. occurred in the Tempe Lake.

f) Exploitation rate

The estimation of the exploitation rate of *Glossogobius* sp. in Tempe Lake was calculated by the following formula proposed by Jones (1984):

$$E = F / Z$$

Where:

E - exploitation ratio;

F - death due to capture;

Z - total death.

The result indicated that the fish exploitation rate was 0.82, while the normal exploitation rate should be of 0.5 (Hadijah et al 2019). Thus, the score for this indicator is 0, which means the rate of exploitation of *Glossogobius* sp. is high. The scoring for the ecological dimension can be seen in Table 2.

Table 2

Score of indicators for the *Glossogobius* sp. management ecological sustainability dimension

No.	*Ecological dimension and indicators*	*Score*	*Information*
1	Water quality	2	Survey data and secondary data
2	Frequency distribution	1	Survey data and secondary data
3	Age of group	0	Survey data and secondary data
4	Growth	0	Survey data and secondary data
5	Mortality	0	Survey data and secondary data
6	Exploitation rate	0	Survey data and secondary data

The result of Rapfish analysis is illustrated in Figure 2. The graph shows that the value of the sustainability index for the ecology dimension is at 32.68, which means less sustainable. Kholil & Dewi (2014) reported that the results of the analysis using Rapfish showed that the level of sustainability of management of fishery resources in the Thousand Islands, the sustainability index for the ecological dimension was 48.63. This illustrates that this ecological dimension must be considered in the context of the sustainability of fishery resources.

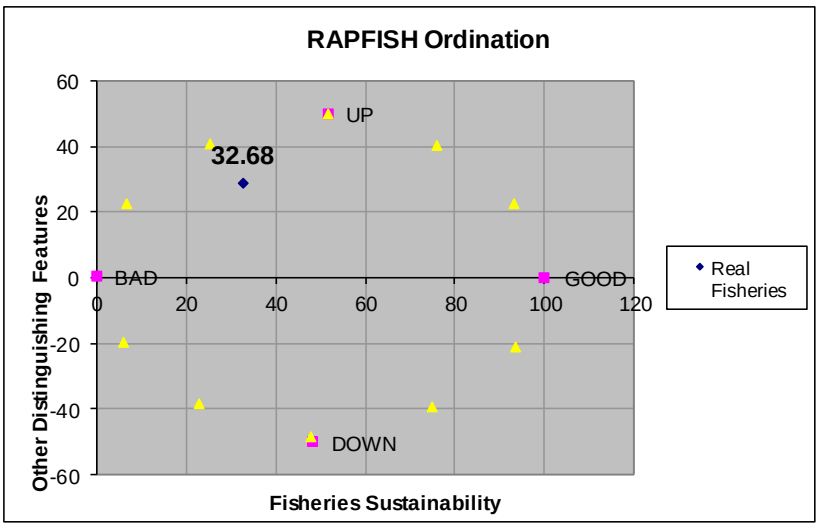

Figure 2. Ecological dimension for the sustainability status of *Glossogobius* sp. in the Tempe Lake.

To determine the ecological condition of *Glossogobius* sp. in Tempe Lake, a statistical analysis was carried out as shown in Table 3 below.

Table 3

Statistical values of Rapfish analysis results on ecological dimensions

No	*Statistical indicator*	*Statistical value*	*Percentage*
1	Stress (S)	0.1442	14.42%
2	R^2	0.9492	94.92%

The determination coefficient (R^2) value was of 94.92% (>90%), in the Rapfish nonmetric Multidimensional Scaling (nMDS). This result confirmed the accuracy of this ordination model. In addition, the stress value (S) was 14.42% (<25%). This shows the goodness and fit of the ecological multi-dimensional model of the sustainability analysis. In the Rapfish model's accuracy evaluation, the maximum acceptable stress value is 25% (Fauzi & Anna 2005).

The sustainability status of *Glossogobius* sp. on the ecological dimension is classified as "less sustainable". The most influential indicators on the ecological dimension consist of five factors such as water quality, length frequency distribution, age group, growth, mortality and rate of exploitation. Leverage analysis is used to determine the level of sensitivity of the criteria for the ecological dimension. The results of the leverage analysis on the ecology dimension indicated that the rate of exploitation, mortality, age group and length frequency distribution of *Glossogobius* sp. had the most dominant and significant effect on the sustainability of the *Glossogobius* sp. (index value >8), while the water quality and growth rate indicators are influential but not dominant and significant because they have an index value <8, as it can be seen in Figure 3. According to Kavanagh & Pitcher (2004), if the indicator index value >8, then it becomes sensitive (a trigger) for that dimension.

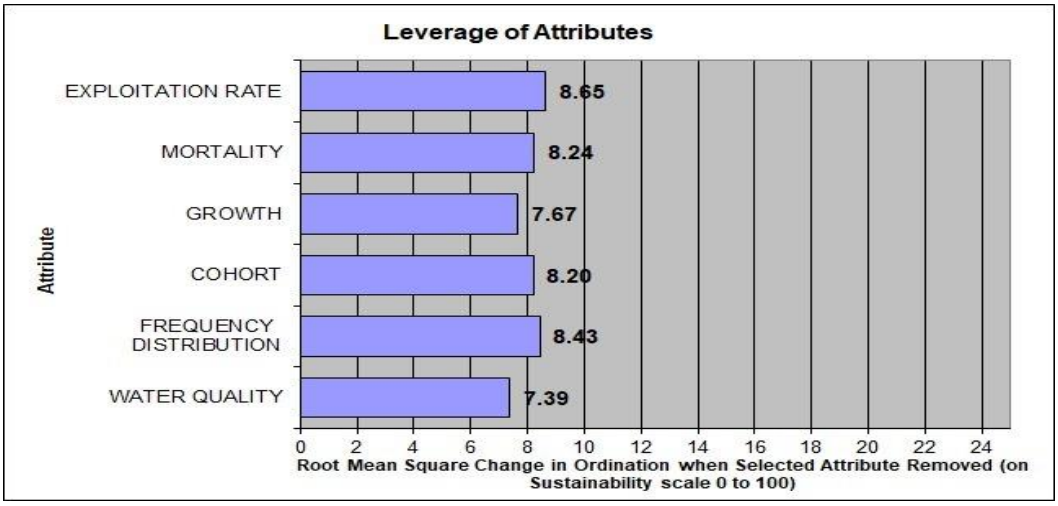

Figure 3. Sensitivity analysis of sustainability indicator of *Glossogobius* sp. on the ecological dimension in Tempe Lake.

Based on the results of the ordination, the sustainability status of the ecological dimension is classified as less sustainable. So in its development and management, an ecological policy is needed that leads to the improvement of sensitive indicators on the ecological dimension. In this dimension, the sensitive indicator the most dominant and significant is the rate of exploitation, mortality, age group and the length frequency distribution of the *Glossogobius* sp. The issue in the ecological dimension is caused by overexploitation. Therefore, a proper control of sustainability of the wild *Glossogobius* sp. populations is required.

Conclusions. The ecological sustainability status of *Glossogobius* sp. is classified as "less sustainable", with the index value of 32.68. The ecological dimension is affected by five indicators, including water quality, length frequency distribution, age group, growth rate, mortality and exploitation rate. According to the leverage analysis performed with the Rapfish, the sensitive indicators are the exploitation rate, distribution frequency, mortality and cohort. Those indicators are known as trigger factors in the ecological dimension, having the potential to improve the overall sustainability index of the *Glossogobius* sp.

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Conflict of interest. The authors declare no conflict of interest.

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